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THE NATURAL HISTORY OF THE GHOST BAT, *MACRODERMA GIGAS* (MICROCHIROPTERA, MEGADERMATIDAE), IN WESTERN AUSTRALIA

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I. INTRODUCTION

My interest in the Ghost Bat, *Macroderma gigas* (Dobson, 1880), was first aroused in 1954. when on August 12 I visited caves in the Jurien Bay area with Dr. D. L. Serventy and other members of the Western Australian Fauna Protection Advisory Committee. Dr. Serventy recognised skulls of these bats, the first records since the early discoveries of live bats further north. Subsequently skeletal remains have been found by several investigators in many coastal caves between the Arrowsmith and Margaret Rivers. I have been able to study much of this material as well as live specimens from the north of Western Australia.

Macroderma gigas was first described from a specimen collected at Mt. Margaret in south-western Queensland in 1880 but there is a much earlier Western Australian record.

Surveyor Robert Austin (1855: 20) reported in his journal of an expedition from Northam to Shark Bay of an ascent of Mt. Kenneth (lat. 28° 57' S., long. 118° 20' E.) on August 17, 1854: "There are some deep caves in the west side of this hill, and in one of them Mr. Whitfield called my attention to a soft black bituminous substance exuding from a cleft in the sandstone rock, and presenting a discoloured line on the lower portion of the back of the cave. While exploring these caves we disturbed and shot two white owls, and saw three large white bats fly out of a crevice in the overhanging rocks, but could not get a shot at them, which I regretted very much, as they were the size of a common pigeon, and brilliantly white." There can be no doubt that these bats were *Macroderma gigas,* the first observation ever reported of the species.

After Dobson described it as new to science, specimens of *Macroderma* were collected in various parts of Australia but so few in the aggregate that the species was believed to be very rare. However Finlayson (1958) in his brief review of the known occurrences expressed the opinion that these bats are really numerous and widespread, and my observations, reported below, support this view.

Macroderma is easily recognised, being white on the underside and dove grey above, but there is some variation in colour and from the Kimberley Division I have described a melanic subspecies (Douglas, 1962). The head and body length of 8 male specimens (all sources, but mostly from the Pilbara) measured by me averaged 113 mm. (ranging from 109 to 127 mm.), that of 15 female specimens averaged 115 mm. (ranging from 102 to 128

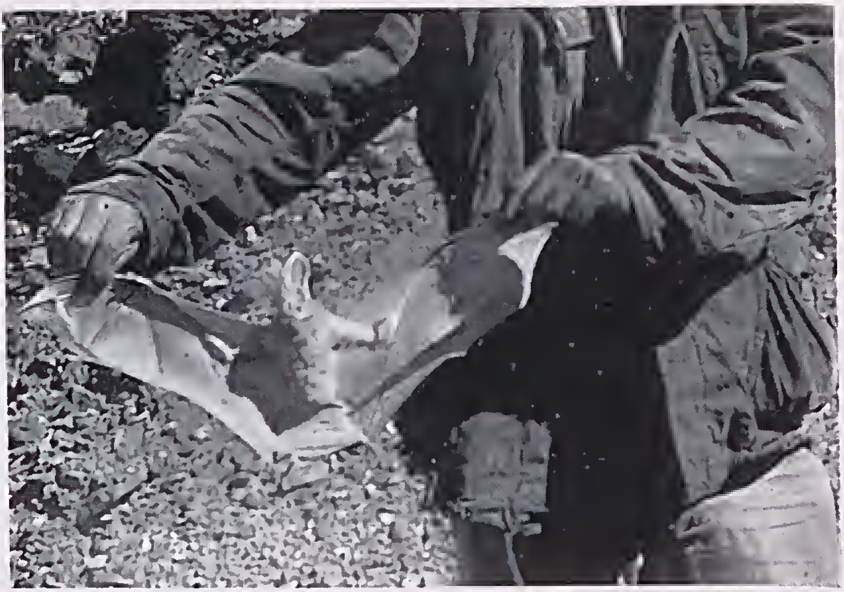

Fig. 1—The Ghost Bat, *Macroderma gigas*. Captured at the Klondyke Queen Mine, Marble Bar, May 25, 1959.
—Photo Dennis O'Mara

mm.). The mean weight of 11 females was 125 gm. (ranging from 108 to 140 gm.), 5 males averaged 110 gm. (ranging from 100 to 123 gm.). The fore-arm lengths, in millimetres, of series of males and females from the Pilbara and Kimberley (and Northern Territory) are as follows:

Area	Sex	No. in sample	Mean	Range
Pilbara	♂	6	106	104-108
	♀	32	108	96-111
Kimberley and Northern Territory	♂	4	102	97-106
	♀	4	105	102-107

2. RANGE AND ABUNDANCE OF *MACRODERMA GIGAS*

(a) Living specimens

The records are arranged in geographical sequence from south to north.

(i) Yalgoo Goldfields District.

Austin's observation of live *Macroderma* at Mt. Kenneth in August 1854 remains the southern-most record of the range of the species since white settlement of the country. On my visit to the area in February 1961 I located the cave described by Austin but there was no indication of the presence of the bat.

(ii) East Murchison and Western Desert.

The most southerly records of live *Macroderma* at the present day are from the Vanaurum Mine, 110 miles east of Wiluna (where Dr. G. F. Mees and I had three clear sightings of a single individual in February 1961) and in a cave in breakaways 65 miles south-west of the Warburton Ranges (where W. H. Butler collected a single specimen in August 1961).

(iii) Ashburton District.

In 1932 Robinson (1957: 232) saw a swarm of *Macroderma* in a cave near Mt. Palgrave in the Barlee Range. The general area, on Ullawarra Station, above Wannery Creek, was re-visited by Mr. Robinson in company with Dr. D. L. Serventy in August 1957. The exact cave could not be re-located but no bats were seen in any of those examined. I had a similar experience during my visit to Ullawarra Station in September 1959 with Mr. Robinson and Dr. J. A. Keast. There is a line of breakaways above the Wannery Creek valley, with red quartzite cliffs at the top, where numerous cavities and caves exist, but we saw no sign of the presence of *Macroderma*.

In the winter of 1960 Mr. G. Low, of the Geological Survey of Western Australia, was engaged in field work in the Capricorn Range (on the Tropic of Capricorn east of Mt. Palgrave). He informed me he had seen *Macroderma* in a cave in the range.

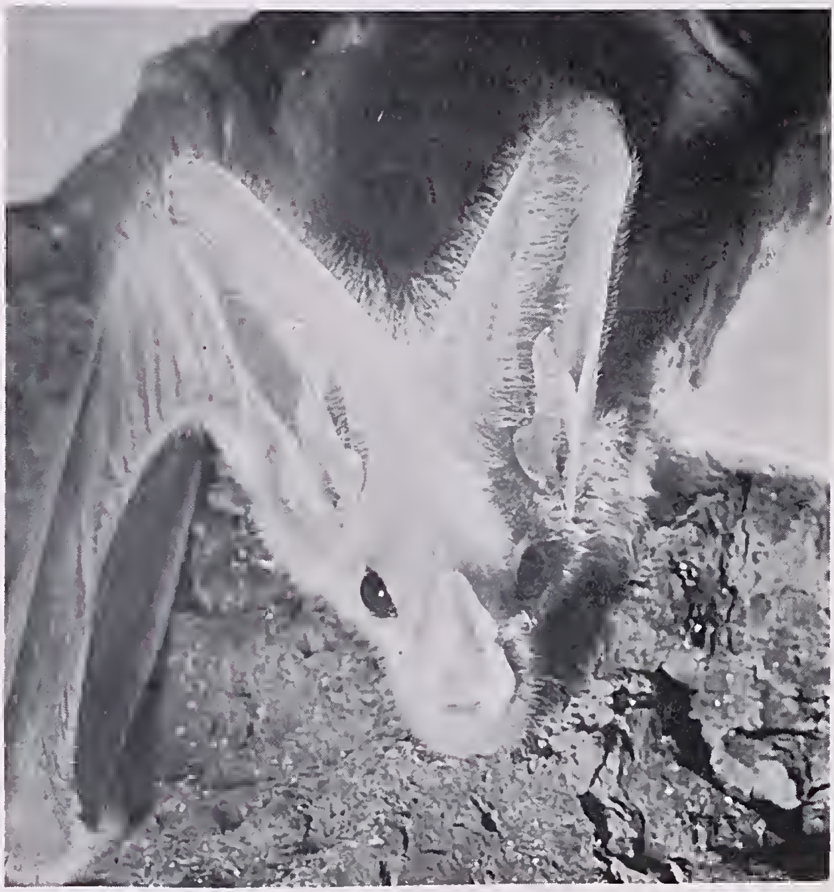

Fig. 2—Frontal view of *Macroderma gigas*. Captured at the Prophecy West Mine, Bamboo Creek.

—Photo W. D. L. Ride

(iv) Hamersley Range.

During the expedition of the Western Australian Museum in July 1958 I examined 30 likely caves in the cliffs and breakaways in the level-bedded quartzites of the Hamersley Range and located *Macroderma* in seven of them—on the northern section of Millstream Station and on Tambrey Station. Two specimens were collected. On a subsequent visit, in June 1959, in the same area *Macroderma* was found in three caves, out of one of which 6 or 7 individuals were flushed. One specimen was caught.

Most caves north of Tambrey Creek showed signs of the presence of *Macroderma* by the occurrence of scat piles.

(v) Pilbara District.

It is here where I have seen most of these bats and whence specimens first reached the Western Australian Museum. Much of the country is rugged with flat valleys and mesa-type topography. Natural caves and rock shelters abound and these are supplemented as bat habitats by numerous abandoned mine workings. The Pilbara has been an important auriferous area since 1888, but in common with other goldfields in Western Australia it has shared in the general decline. Many of the mines and tunnels have been abandoned for so long that they are virtually inaccessible except under guidance. Pastoral activity preceded mining in the settlement of the Pilbara by more than 20 years, and over much of it a serious over-grazing problem exists. However the hilly country has been less detrimentally affected by sheep and here restricted patches of more or less unspoilt habitat survive.

The first specimen of *Macroderma* from the Pilbara district was reported by Waite (1900: 188) and thereafter occasional specimens were received at the W.A. Museum. Between 1956 and 1966 I made nine visits to the area and observed or collected the species in numerous mine workings and natural caves. From my observations and museum data the species has been recorded at the following places: Ophthalmia Range (in an old copper mine), Whim Creek (Whim Well Mine and in a long adit some miles north of it), Woodstock Station (recorded by the late Mr. Justice T. P. Draper and Dr. E. H. M. Ealey, and by myself in a cave in a granite outcrop known as Eagle 2), Marble Bar district (almost every mine examined has evidence of the occurrence of *Macroderma;* particular mention may be made of the North Pole, Comet, Klondyke Queen, Coronation and The Trump Mines), Bamboo Creek area (Bamboo Queen, Cave, Kitchener, Prophecy West, Little Mickey and Mickey Extended Mines), Nullagine district (The Elsey, All Nations, Hopetoun, Little Wonder and Mountain Maid Mines), and Ripon Hills.

At eight of the localities I have examined, 20 or more individual bats were counted. The most numerous aggregation was at the Klondyke Queen Mine on May 28, 1959, where at three levels I counted a total of 287 individuals but I could not determine how many of these were repeat sightings. I netted 30 specimens, of which 21 were females and 9 males. The All Nations Mine at Nullagine is inhabited by at least 150 *Macroderma.*

As may be expected the temperature at the bat roosts remains very equable compared with that outside. At the Comet Mine, Marble Bar, on May 26, 1959 the temperature inside was 70° F. and 86° F. outside. In a mine adit at Eastern Creek on May 18, 1959 it was 68° at 2 p.m. and 80° outside; just before dawn, at 4.30 a.m., it was still 62° in the mine but the temperature had dropped to 53° outside.

(vi) Kimberley Division.

The populations of *Macroderma* in the Kimberley Division (and Northern Territory)—*Macroderma gigas saturata* Douglas, 1962—differ markedly in colour from those further south in Western Australia whose distribution has been discussed in the previous sections. The northern bats have been found at the following places:

At an island near the Bathurst Islands, just north of King Sound, a single individual was seen in each of three caves (Douglas, 1956).

W. H. Butler discovered a large colony on nearby Koolan Island and collected a specimen from Pigeon's Cave in Tunnel Creek on Fairfield Station in June-July 1965.

A specimen from Napier Range was received at the W.A. Museum in 1960.

I collected numerous *Macroderma* scats and portions of skeletons from Blakeley's Mine, 30 miles east of Hall's Creek in 1966.

There is a specimen from Mt. Anderson Station in the W.A. Museum collection received in 1931.

Finally, at the extreme north, a large population exists at the Kalumburu Mission on Napier Broome Bay, which I visited in June and July, 1960. In one cave alone I netted 180 *Macroderma.*

(b) **Cave Remains**

The records are dealt with in geographical sequence, from north to south.

(i) Between the Arrowsmith River and Jurien Bay.

At the Arrowsmith Cave near Arromel Lake P. Bridge found skeletal material, including skulls, in 1963.

At the Weelawadgi Cave near Eneabba G. Hitchin found similar material on February 28, 1965.

(ii) Coorow.

In a cave on Mr. Spillwindier's farm, west of Coorow, on April 8, 1961, Dr. S. J. J. F. Davies found skulls and bones. As in all the cave occurrences listed in this section, except where otherwise mentioned, the material was found lying on the surface in the floor of the cave.

(iii) Watheroo.

At Bishop's Cave near Watheroo J. Lowry collected skulls and bones on March 27, 1963.

(iv) Jurien Bay Caves.

The State Fauna Advisory Committee, on its tour in August 1954, was guided through several caves in this neighbourhood by Mr. F. Grigson, of Cockleshell Gully Farm. D. L. Serventy found several skulls of *Macroderma* in two caves near what is known locally as the Drover's Cave. Serventy visited the caves again a month later, and made further collections. The *Macroderma* skulls were collected from the surface near the cave walls. In two of the caves were accumulations of bat guano which were being mined at the time. Rodent and marsupial material were associated with the *Macroderma.* No live bats of any species were seen at the time. Mr. Grigson, who is a keen field naturalist, had never seen a bat answering to the description of *Macroderma* during his long residence in the district.

On a second visit to the area in May 1958 I made a detailed examination of one of the caves previously visited by Serventy—the Smith's Cave, whose guano was being worked as a commercial source of fertiliser. A deposit above the present floor of the cave had all the superficial appearance of old *Macroderma* scat piles in the Pilbara cave roosts. On treatment the result was found to be identical with the end result of fresh *Macroderma* scat piles, except for the occasional presence of a large bone, or teeth, with limestone debris. These samples differed from the material in the guano accumulation in the main body of the cave in that the bone was chewed into small fragments and no particles of wood or charcoal were found. In other words only the deposit above the level of the main guano heaps appeared to be the result of *Macroderma* occupancy. I visited the cave again in April 1959 and found another similar high level deposit, from which I collected a single tooth of an immature *Macroderma* among the finely masticated bones of a treated sample.

Lundelius (1960) reports a stratigraphic investigation of several of these caves. At Drover's Cave he found *Macroderma* remains in a trench down to 5 ft. in depth. At Wedge's Cave *Macroderma* occurred down to 6 ft. in depth. P. J. Bridge also later collected *Macroderma* bones in Wedge's Cave.

At the Namban River *Macroderma* remains were collected by Bridge in The Pretty Cave in 1963.

(v) Dandaragan District.

P. Bridge has collected skeletal material in a cave in this district.

(vi) Gingin District.

In 1958 E. Glasson investigated a cave 26 miles north-west of Gingin and presented the W.A. Museum with two scapulas of *Macroderma* which he found there.

(vii) Yanchep.

Lundelius (1957: 180) recorded remains in superficial deposits at Yanchep which, at the time he wrote, was considered to be the furthest south occurrence of the species.

(viii) Margaret River District.

Cook (1960) recorded a skull he found in March 1959, in the Nannup Cave, near Boranup Mill, south of Margaret River on the Caves Road. This at present is the furthest south record of the species. The skull was collected 20 in. below a sheet of dripstone associated with extinct and recent species of marsupials and unidentified rodent material.

The distribution pattern, as revealed by the above data, is given in Fig. 3. A distribution map for Australia as a whole is given by Hamilton-Smith (1966, fig. 2B).

I find it difficult to offer an adequate explanation for the absence of *Macroderma* in the more southerly localities at the present day, and the reason for the contraction of its range to the Western Desert, the North-West and Far North. Wood Jones (1925: 444) in discussing the sub-fossil remains at the Carrieton Caves, east of Port Augusta in South Australia, considered the species had disappeared from this general area owing to the climate having become drier. In view of the desert occurrences of the species, made known subsequently, this explanation fails, as pointed out by Butler (1961), who believes in quite a contrary explanation, namely that *Macroderma* is really a desert animal and "its former presence in southern localities may be evidence of a more arid climatic interval at that time," A similar interpretation of the evidence is given by Ride and Serventy (1965: 70). Hamilton-Smith (1966: 98) is disinclined to accept either of

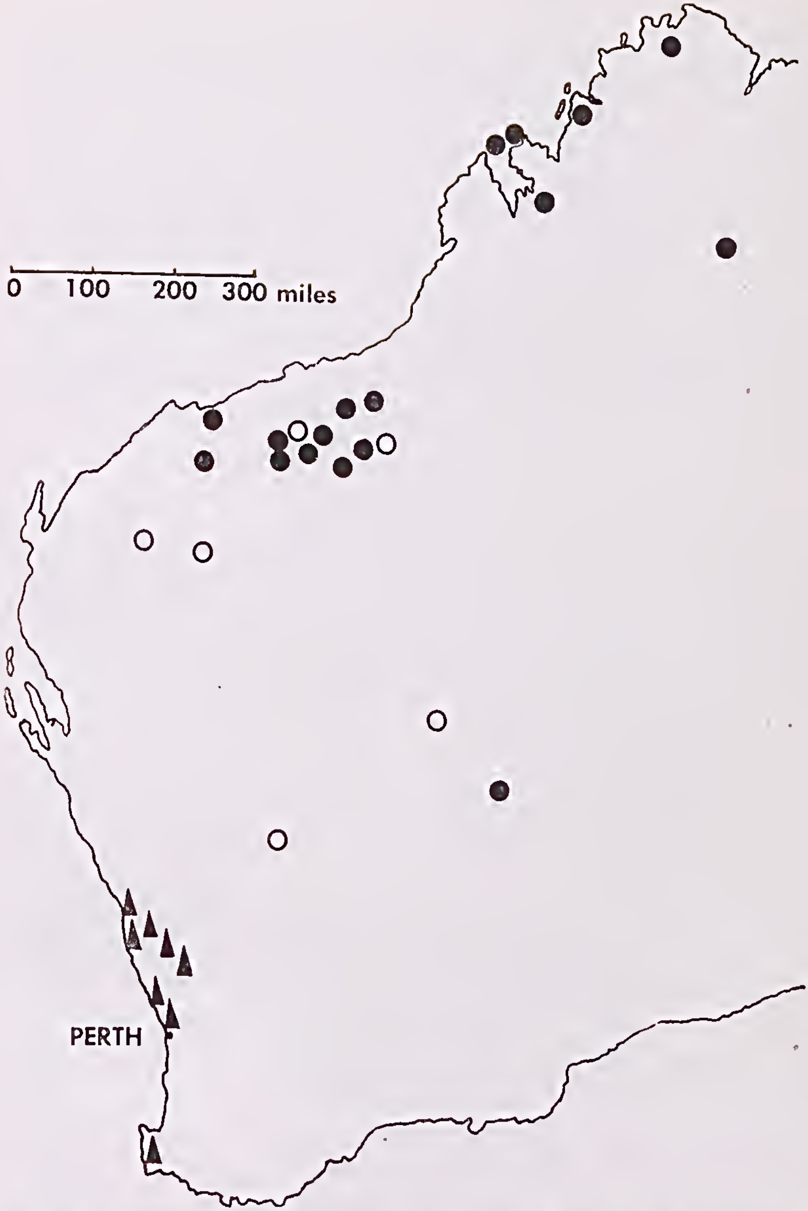

Fig. 3—Distribution of *Macroderma gigas* in Western Australia. Solid black dots represent records based on collected specimens; open circles, sight observations; black triangles. skeletal remains from caves.

these explanations and, like myself, is at a loss in proposing another.

However he draws attention to the possibility of temperature being a significant factor but does not elaborate on how it might operate. He also refers to the possibility of a decrease in the food supply being a factor in the problem. There might be some merit in this latter suggestion and it warrants following up, particularly to assess the amount of food *readily accessible* to this bat under current climatic conditions rather than the amount of food that is actually there. Under present conditions in South-Western Australia, for instance, *Macroderma* might find hunting very poorly rewarding in the heavily timbered sclerophyll forests and woodland with their abundant shelter for small creatures. Prey, even if somewhat less abundant, would be much easier found and caught in the more open arid country and in the savannah woodlands of the Far North. Naturalists are familiar with the fact that even diurnal birds of prey appear to be more numerous, individually and in number of species, in the drier parts of the State than in the humid South-West corner—a fact first pointed out to me by the late Major H. M. Whittell. Thus an explanation for range fluctuations in *Macroderma* more in keeping with Butler's theory might prove the eventual answer.

3. FOOD OF *MACRODERMA GIGAS*

(a) Hunting Methods and Feeding

Macroderma emerges from its cave shelters after sunset and returns before dawn. In the Pilbara district and at Kulumburu I have watched outside *Macroderma* caves and rigged drop-nets outside the entrances to check their movements. The first bats left about an hour after sunset but others might not venture out until an hour before midnight. Sometimes individuals might remain in caves all night. The return times also varied greatly. Some individuals returned before 10 p.m., others just before dawn. They might leave singly, in two's, three's or in groups of up to a dozen or so individuals.

Excepting for the record near King Sound (Douglas, 1956) and some information gained at Kulumburu, all my observations of *Macroderma* capturing prey have been on captive individuals confined in a room or cage, where their movements would necessarily be restricted.

Unlike the great majority of Microchiroptera, which are not endowed with good vision, *Macroderma* can see quite clearly. When disturbed in lighted caves they quickly take up a point of vantage and keep an intruder under scrutiny. When driven out into the open they hold their heads high, as if scanning the country-side for alternative shelter. At Marble Bar in 1957 I let two captive *Macroderma* loose in a room and they would swoop down on food placed on the floor—but only when no-one was in the room. Whenever I entered they would follow my every movement and their beady black eyes gave an impression of extreme alertness.

The bat preferred to drop on mammals (mice were given them in captivity) from above, enveloping them with its wings and uropygium, and biting at the head and neck until all movement ceased in the victim. Dead birds were grasped across the chest, reptiles and frogs mostly across the head. The tails of reptiles were disregarded if they broke off. After the victim was motionless *Macroderma* grasped it by the back of the neck, shuffled backwards until it reached the edge of the cage, when it climbed to a high point and began to eat.

A captive female held in a tea-chest cage (3 ft. x 2½ ft. x 2½ ft.) was given a live mouse, which it attacked and killed within two minutes. The bat climbed up the hessian lining towards the top of the cage, where the lid had been removed. On finding itself free it immediately took flight and spiralled upwards in the room to a ventilator. Here it consumed its meal, devouring it within half-an-hour. The bat was at liberty in this room for five days, descending from its ventilator roost to take from the floor any food that was offered to it—large insects, birds, mice and fresh meat. But it would not fly down until all persons had left the room.

At the islet near the Bathurst Islands I observed a *Macroderma* swoop down on a bat, *Taphozous georgianus,* which I had just shot within its cave.

Prey seems to be eaten at the point of capture, or taken to a favourite spot. My only field evidence on this point is from observations made by Fr. S. Sanz at Kalumburu. Insects, frogs, geckoes and other lizards were captured from the walls of the mission building and carried either to the church porch or to a protected alcove to be eaten. Remnants of the prey (tails, gut of frogs, wings of beetles and moths) would be dropped to the ground. Unfortunately at the time of my stay (June-July) *Macroderma* had ceased their nightly visits as it was the dry season and few frogs, lizards and insects frequented the mission precincts.

When *Macroderma* is feeding young the food is apparently taken direct to the roosting caves.

Captive bats will always accept food and the amount eaten seems surprisingly large. When insufficient amounts of food are offered a rowdy squabbling takes place until the disposal of available food is settled between them. Two captive bats ate two white mice in 24 hours. A hungry bat completely consumed a mouse in 45 minutes. A male (wt., 115 gm.) and a female (wt., 108 gm.) ate 6 live ¾-grown white mice (weighing c. 110 gm.) over a period of 2½ days. At Tambrey Station a live small bat *(Taphozous)* was offered to a captive *Macroderma* in the evening; it was completely eaten in 36 minutes. Two hours later the bat ate 25 gm. of the heart muscle of a duck in 15 minutes, and during the night killed and ate another live *Taphozous.*

Captive bats accepted a great variety of food, little discrimination being shown between the kinds of prey offered to them. However some preferences became apparent. Living food was preferred to dead; mice and small bats were freely eaten, so were small dead birds, legless lizards (Pygopodidae), geckoes and small snakes *(Denisonia* and *Rhynchoelaps).* But small Agamid lizards and skinks were eaten only when nothing else was available. Sufficient insects were not used in the feeding experiments to gauge preferences, but moths, crickets, grasshoppers, beetles and all large insects were readily accepted. When raw meat was given, especially liver, the bats soon became distressed because of the semi-fluid nature of the faeces which fouled the pelage, body and head. However when subsequently fed on insects, whole birds and whole mice such bats recovered rapidly and their faecal pellets fell free from the body. Vegetable matter was also taken. Fruit was always available in the cage and it was noticed on many occasions that it had been eaten in small quantities. Pawpaws and bananas were eaten but only sparingly. However when animal food was available the bats ignored the fruit.

In eating mammals the bats ingested the whole carcase including the fur. With birds feathers were discarded where possible and tail and wing quills, and the legs, were dropped before ingestion.

Macroderma is a messy eater and portions of a meal might be dropped on the ground—this might include tails of mammals and lizards and even larger parts of the prey. These are never or seldom recovered and it appears that under natural conditions the bat does not feed upon the ground. Mastication is excellent, bones being chewed so finely that very little of an identifiable nature was voided in the faeces. Occasionally molar teeth of rodents and marsupials remained intact in the scats, but teeth were mostly found broken.

Large masses of fur and small feathers are a feature of the stomach contents of the *Macroderma* I have dissected. This indigestible matter is always voided in the faeces and never ejected as a bolus in the manner of such birds as owls and crows. I have never found evidence of a bolus either in their caves or below their roosts. The scats invariably contain indigestible matter such as hair, feathers, comminuted bone and insect chitin. Defaecation of such material may be prolonged. On one occasion I fed captive bats for five days on birds and the stomach material still contained some mammal hair from a previous meal. Hairs from white mice fed to two bats were being evacuated in the scats six days after the last mouse had been devoured.

(b) Food Remains in Situ.

As stated previously *Macroderma* normally eats its prey at or near the point of capture. However when feeding young the food is taken direct to the roosting caves. Here feathers and other material may be dropped and become intermingled with the scat piles. During investigations in *Macroderma* haunts in caves and mine workings in the Pilbara district identifiable parts of various organisms were found among the dropped food remains. Birds and small mammals were plentiful and I have insufficient data to be sure which group predominated. Reptile remains were not so frequent.

Mammals: The introduced house mouse, *Mus musculus,* was the commonest species represented. It was followed in order of abundance by native rodents, *Leggadina cf. hermannsburgensis.* There were occasionally small dasyurids such as *Sminthopsis,* and one specimen each of *Antechinus rosamondae, A. macdonnellensis* and *Sminthopsis longicaudata.* Compared with these mammals small bats were definitely not numerous, but I identified remains of three species: *Eptesicus pumilus, Taphozous georgianus* and *Miniopterus schreibersi.*

Birds: Some 20 species of birds were identified from feathers and occasionally heads. The most frequently occurring species was the Budgerygah *(Melopsittacus undulatus),* followed by the Owlet-Nightjar *(Aegotheles cristatus)* and the Grey-headed Honeyeater *(Meliphaga keartlandi).* Diamond Dove *(Geopelia cuneata)* and Painted Finch *(Zonaeginthus pictus)* were fairly common. Strangely the Zebra Finch *(Taeniopygia castanotis* did not figure plentifully in the remains. The Owlet-Nightjar, Honeyeater and the Painted Finch are characteristic species of the rocky habitats which are associated with the occurrence of *Macroderma.*

The following is a list of the species identified: Little Quail *(Turnix velox),* Diamond Dove *(Geopelia cuneata),* Red-plumed Pigeon *(Lophophaps ferruginea*—the largest bird in the series examined), Budgerygah *(Melopsittacus undulatus),* Owlet-Nightjar *(Aegotheles cristatus),* Kingfisher *(Halcyon sp.),* White-backed Swallow *(Cheramoeca leucosternum),* Australian Pipit *(Anthus novae-seelandiae),* White-winged Triller *(Lalage sueurii),* Cinnamon Quail-Thrush *(Cinclosoma cinnamomeum),* Rufous Songlark *(Cinclorhamphus mathewsi*—doubtful indentification), Striated Grass-Wren *(Amytornis striatus),* Hooded Robin *(Petroica cucullata),* Grey Fantail *(Rhipidura fuliginosa),* Black-tailed Treecreeper *(Climacteris melanura).* Singing Honeyeater *(Meliphaga virescens),* Grey-headed Honeyeater *(M. keartlandi),* White-plumed Honeyeater *(M. penicillata),* Painted Finch *(Zonaeginthus pictus),* Zebra Finch *(Taeniopygia castanotis)*, and Black-faced Wood-Swallow *(Artamus cinereus)*.

Reptiles: The commonest lizard found was *Physignathus longirostris*, and I also recorded various other agamids and *Gehyra australis, Delma* and *Lialis burtonii*.

[Amphibia: No remains of frogs were noted in the Pilbara scat piles, but I may mention here that at Kulumburu Fr. Sanz observed *Macroderma* feeding on *Hyla nasuta*.]

Insects: Coleoptera, Orthoptera, and Lepidoptera.

In the stomachs are also found numerous seeds, which I presume are from the bodies of seed-eating birds.

4. BEHAVIOUR AND GENERAL HABITS

Macroderma appears to be exclusively a cave haunting bat. It occurs alike in deep natural caves and in shallow caverns in breakaway country, deep rock fissures, and in mine shafts and tunnels. It may also frequent buildings as feeding stations but not as roosts. Thus at Kulumburu the missionaries were kept awake by *Macroderma* noisily eating prey in the church entrance and in the corridors. where the bats dropped food remnants on the floor. This was such a problem that on the eve of a visit by a church dignitary the corridors were drop-netted by Fr. Sanz and a large number of bats were trapped.

The extent of daily and seasonal movement is unknown. In the Kimberley Division a distinct seasonal shift in feeding location has been observed. Thus the church-frequenting episodes just described come under notice only during the summer (the "Wet" in local parlance) and the bats were never seen feeding at buildings during the winter (the "Dry").

In their natural haunts the bats are generally silent and so unobtrusive that residents are usually unaware of their presence. Miners and other residents in the Pilbara, where bats are abundant, often mention the occurence of the small *Eptesicus* and *Taphozous* but usually disclaim knowledge of *Macroderma*. Only once, at Kalumbura, have I heard any sound from *Macroderma* under field conditions. This was when I trapped over 70 bats in a small cave by means of a nylon net set across their escape tunnel. The sounds emitted resemble that made by two pennies being rubbed together. In captivity the bats often make a noise similar to the "chi-r-r-p" of a cricket and this may continue at intervals through the night. This particular sound is most used when the animals are hungry. When they are fighting over food, or through general irritability, their voices may be raised in high-pitched squeals, similar to those of squabbling flying foxes *(Pteropus)*. At intervals during the night, and occasionally in the day-time, they make the coin-rubbing sound already alluded to. This may be a call of reassurance to each other's proximity. Young *Macroderma* when separated from their parents emit continued squeaks.

Macroderma flies a smooth straight course, with the head held high, appearing to scan the surroundings as to where to go. The flight is very similar to that of the Silver Gull *(Larus novaehollandiae)*. Further references to flight characteristics have been made in the section on feeding and hunting habits.

The animals are very nervous and alert when an intruder enters their cave roost. At the slightest disturbance they will take flight and vacate the cave. This is done so inconspicuously that the intruder is often unaware of the bats and his first intimation that *Macroderma* is present is often a warning from someone outside the cave, or mine shaft, that the bats are emerging.

Apparently *Macroderma* does not employ its echo-location mechanism continuously. Intruders at mine entrances have often been hit by emerging bats but after the initial collision the bats realise that obstructions are present and the echo-location apparatus is called into play. At any rate there are no further mishaps.

Macroderma has a characteristic musty odour which to me is specific and distinguishable from that of all other bats.

I have found that in contrast to the small bats *Macroderma* is consistently free of obvious parasites, both external and internal.

In the Pilbara there is associated with most long established bat colonies a cockroach, *Paratemnopteryx atra* (Princis, 1963), which is abundant on faecal piles deep in mines.

5. REPRODUCTION

The female *Macroderma* has both pectoral and inguinal mammae, and these become turgid in pregnant females. In the case of young virgin *Macroderma* the mammae are hard to detect, but with adults which have given birth to young both inguinal and pectoral mammae are easily seen. The clitoris is enlarged in the adult.

Among the piles of faeces and dropped food remnants below roosts young dead bats are often found and it appears that females congregate in groups when carrying or feeding young. I do not know whether there are males in these groups as well. Young bats are left at the roost while the female parent hunts and some may fall during her absence or in the excitement attendant on her return.

Sometimes a male or a female is found solitary; on one occasion (in the Cave Mine at Bamboo Creek in October 1957) a small group, entirely of females, was found. All other groups have been of mixed sexes or of undetermined sex. In groups with both sexes females usually outnumber males by about five to one.

No observations of mating have been made.

Dates of Embryos and Young in the Pilbara District

An embryo of c. 10 mm. crown-rump length (i.e. around the curve of the body) was dissected from a female *Macroderma* collected at Tambrey Station on August 1, 1958. Three embryos (of crown-rump dimensions of 52 mm., 65 mm., and 70 mm.), all males, were taken from bats collected at the Klondyke Queen Mine, Marble Bar on October 15, 1957. These measurements were taken from spirit specimens.

On November 16, 1960 I found a newly-born dead *Macroderma* in an adit near the Comet Mine, Marble Bar; it still had part of its birth membranes attached.

On November 20, 1956 I came across a large number of females with young attached in the All Nations Mine, Nullagine. In one stope there was a cluster of about 40 parent bats and in an open cut north of the main shaft there were about 20 clustered on a wall. I shot 13 of these adult bats; they were all females with young. No crown-rump measurements of the young were made but their lengths (chord) ranged from c. 60 to 80 mm. I assume they were still being fed by the mothers and had not yet attempted solid diet.

From the above data it would appear that in the Pilbara the young are born towards the end of October or early in November.

Dates of Embryos and Young in the Kimberley Division and Northern Territory

On June 23, 1960 at Kalumburu I dissected from a female an embryo which measured 45 mm. in crown-rump length.

On September 19, 1964 at Pine Creek, Northern Territory, I collected a hairless young *Macroderma* which had been left alone by its mother; it was a male and had a crown-rump measurement of 96 mm., and a length (chord) of 80 mm.

From these admittedly slender data there is an indication that the breeding season in the Far North (of the subspecies *saturata)* is decidedly earlier than in the Pilbara.

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Dr. W. D. L. Ride, Director of the Western Australian Museum, accompanied me in the field on several of the occasions mentioned here. Dr Ride also, and Dr. D. L. Serventy, of the C.S.I.R.O. Division of Wildlife Research, helped during the preparation of the paper. Mrs P. Sundstrom kindly prepared the distribution map on page 131.

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SUMMARY

Records of past and present distribution of the Ghost Bat, **Macroderma gigas** (Dobson) in Western Australia show that the range is shrinking and the animal is now restricted to the arid country in the Western Desert, and also to the North-West and the Kimberley Division. In Sub-Recent times it occurred much further south, and as far as the Margaret River. The bat is a cave-inhabiting species and it has taken also to live in abandoned mine shafts in the Pilbara district. It feeds on small mammals (mainly rodents and small marsupials, and to a lesser degree on the smaller bats), small birds (mainly Budgerygahs and Owlet-Nightjars), reptiles and insects. Small embryos are found in females in the Pilbara district in early August and the young are born towards the end of October or early in November. In the Kimberley Division the breeding season is earlier.

FROM FIELD AND STUDY

Green Pygmy-Goose near Perth.—On March 4, 1967, accompanied by Arthur Tydeman, I visited Jandalup Lake, which lies about 3 miles inland and 5 miles north of North Beach. At approximately 9 a.m. I saw two very small, pretty ducks with white face patches below the eyes and heavily barred breasts and flanks; the necks and upper-parts looked a dark brown from where we were stationed not more than a hundred yards away.

I immediately identified these as Green Pygmy-Geese, *Nettapus pulchellus,* as I had been familiar with this species only a week previously, and in the company of Don Tulloch, at Knuckeys Lagoon near Darwin. My companion confirmed the identification and *pulchellus* was added to our list without further thought. It was not until I was told of this bird's rare occurrence in South-Western Australia that I realised I had seen anything unusual. The birds did not appear to be present on the following day.

—B. D. BOND, Malacca, Malaysia.

[Mr. Bond discussed this observation with me. The only specimen of this species collected in the South-West was taken by T. L. Riggert at Moora on January 8, 1966. Other observations are summarised in the *Birds of Western Australia,* Serventy and Whittell, 4th. edn., 1967: 147.—D.L.S.]

Another Record of the Spur-Winged Plover.—The Spur-winged Plover, *Lobibyx novae-hollandiae,* has been recorded in the South-West of this State only rarely and I submit this record of a solitary bird which I believe to be of this species.

It was on the edge of the sand flat near shallow water just inside the entrance to Wilson Inlet, approximately four miles from Denmark, during the last week of December 1965. Other birds in the vicinity included Silver Gulls, Crested Terns, sandpipers and a pair of Sooty Oystercatchers.

I was not sure of the identity of the species at the time, whether it was the Spur-winged or the very similar Masked Plover *(L. miles)*. However, after referring to the drawings of both species, done by Mr. Peter Slater, I feel certain that the bird I saw was the Spur-winged Plover.

(Mrs.) N. GRAY, Claremont.

Black Falcon in Metropolitan Area.—At my home in Wembley I looked up into the eastern sky at 7.20 p.m. on January 3, 1967, and saw what at first glance appeared to be a crow. The bird was